The SandyDuck '97 Nearshore Field Experiment

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LONG-TERM GOAL

This effort provided the logistic framework for the SandyDuck nearshore field experiment conducted during the summer and fall of 1997 at the Field Research Facility (FRF) of the US Army Engineer Waterways Experiment Station located in Duck, NC. SandyDuck culminated a seven year planning effort that included a pilot experiment, DUCK94. SandyDuck was cosponsored by ONR, the US Army Corps of Engineers and the US Geological Survey.

SCIENTIFIC OBJECTIVES

SandyDuck scientific objectives developed from a series of meetings and discussions within the nearshore science community. From this effort, the SandyDuck steering committee established specific objectives as fundamental to improved understanding of surf zone sediment transport:

- *small and medium scale sediment transport & morphology (sediment grains to 100 m scale);*
- *wave shoaling, wave breaking, and nearshore circulation;*
- *swash processes including sediment motion.*

APPROACH

A successful field experiment required close coordination between the Steering committee, the 5-person Logistics committee, the program managers of the sponsoring agencies and the principal investigators. After the final set of experiments were selected, the logistics committee established a calendar for the experiment including sensor deployment and removal activities and they defined the required experiment infrastructure and budget. The Field Research Facility provided infrastructure support along with basic environmental measurements and mapping.

WORK COMPLETED

Planning activities began with a first and only meeting with all investigators held in December 1996. Eleven leased trailers arrived in June and were quickly furnished and equipped with Internet connections, telephone service, and emergency power.

The first research group arrived in June and instruments deployments began 5 July. Good weather and a well thought-out schedule permitted instrument deployments to continue smoothly until the experiment technically began 22 September. Table 1 lists the 30 participating organizations including those under ONR sponsorship (numbers 6, 7, 9, 11, 12, 13, 14, 16, 17, 18, 20 and 23).

Table 1. SandyDuck Participating Organizations		
Sponsors	**1**	**US Army Engineer Waterways Experiment Station**
	2	**United States Geological Survey**
	3	**Office of Naval Research**
Agencies	**4**	**National Oceanic and Atmospheric Administration**
	5	**Naval Research Laboratory**
	6	**Naval Postgraduate School**
Universities	**7**	**Dalhousie University (Canada)**
	8	**Duke University**
	9	**Memorial University of Newfoundland (Canada)**
	10	**North Carolina State University**
	11	**Oregon State University**
	12	**Scripps Institution of Oceanography**
	13	**State University of New York, Stony Brook**
	14	**University of California, Berkeley**
	15	**University of Delaware**
	16	**University of East-Anglia (United Kingdom)**
	17	**University of Florida**
	18	**University of Manitoba (Canada)**
	19	**University of South Florida**
	20	**University of Washington**
	21	**University of Wisconsin, Eau Claire**
	22	**Virginia Institute of Marine Science**
	23	**Washington State University**
	24	**Woods Hole Oceanographic Institution**
Companies	**25**	**Areté Associates**
	26	**Offshore & Coastal Technologies, Inc**

The experiments are listed in Table 2 ordered by last name of the lead investigator. ONR sponsored experiments in Table 2 are in bold and include numbers 1, 2, 5, 8, 9, 11, 13, 18, 23, and 26.

The SandyDuck surf zone array of point instruments is shown in Figure 1. Not shown are additional instruments deployed across the inner shelf out to a depth of ~25 m.

Central to the surf zone array are instrument frames (5, numbers refer to investigations number in Table 2), each containing an electro-magnetic current meter, a pressure gauge, an acoustic altimeter, and a thermometer. Drs. Elgar, Herbers, O'Reilly, and Guza deployed these frames (small "+" signs in Figure 1) in multiple lines, and at varying spacing, in order to measure nearshore dynamics and bed level changes both cross-shore and longshore.

Drs. Thornton and Stanton (26) deployed a spatial array of manometers (small solid circles in Figure 1) which should provide a precise measurement of the water surface slope, critical to understanding longshore currents. In addition, they deployed a highly instrumented sled equipped with new and traditional instruments for measuring nearshore dynamics, bedforms, and sediment transport. Drs. Thornton and Stanton also added digital sonar-altimeters to the FRF's *CRAB* (a 10-m tall tripod vehicle) to map bottom bedforms as the CRAB surveys the "minigrid" area. Also mounted on the CRAB to observe spatial coverage of bedforms was Drs. Drake and Snyder's (2) side-scan sonar.

A large number of suspended sediment concentration gauges were deployed, including optical backscattering sensors (6, 7, 21), the innovative and less intrusive fiber-optic backscattering sensors (1, 21), and acoustic concentration profilers (8, 9).

Most array positions included one or more current meters (1, 5, 6, 7, 8, 9, 15, 23, 25, 29). Dr. Smith's (23) two secscan sonars, used in combination look toward the beach and provide two-dimensional (horizontal) maps of the velocity field. Surface wind-stress was monitored at the end of the FRF's research pier (4, 20). Incident wave conditions were monitored by directional wave buoys (11, 16) and a direction-sensing array of pressure gauges (20).

Table 2. SandyDuck Experiments

(number in parentheses refers to Table 1, ONR projects in bold)

No	Investigators	Experiment Title	Wave Shoaling	Nearshore Circulation	Boundary Layers	Swash Processes	Small Scale Sediments	Meso/Macro Morphology	Water Properties
1	**Beach(11), Holman(11), Sternberg(20), Ogston(20), Conley (13)**	**Fluid-sediment interactions in the surf zone**		**X**	**X**		**X**		
2	**Drake(10), Snyder(10)**	**Side-scan sonar studies of nearshore morphology in the vicinity of Duck, NC**						**X**	
3	Dugan(25)	Nearshore measurements for long-range remote sensing		X				X	
4	Edson(24)	Application of a marine surface layer model to the Coastal Environment			X				
5	**Elgar (23), Herbers(6), O'Reilly(14), Guza (12)**	**Surf zone waves currents and morphology**	**X**	**X**		**X**		**X**	
6	Friedrichs(22), Brubaker(22), Wright(22), Vincent(16)	Cross-shoreface suspended sediment: a response to the intersection of nearshore and shelf processes		X	X		X		
7	Haines(2), Gelfenbaum(2), Wilson(2)	Vertical structure, bedforms, turbulence		X	X		X		
8	**Hanes(17),Vincent(16)**	**Near bed intermittent suspension**		**X**			**X**		
9	**Hay(7), Bowen(7), Doering(18), Zedel(9)**	**Nearshore sediment dynamics: suspension, bedforms, and bubbles**		**X**	**X**		**X**		**X**
10	Heitmeyer(5)	Surf-noise experiment							X
11	**Herbers(6), O'Reilly(14), Guza(12)**	**Wave propagation across the continental shelf**	**X**						
12	Holland(5), Sallenger(2)	Swash zone morphology				X			
13	**Holman(11)**	**Large scale morphology**						**X**	
14	Howd(19), Beavers(8)	Geologic signature of storm events on the inner continental shelf and outer surf zone						X	
15	Howd(19), Hathaway(1)	Shoreface processes and bed response	X	X				X	
16	Jensen(1)	Evolution of wave spectra in shallow water	X						
17	Jol(21)	Ground penetrating radar of the beach						X	
18	**Lippmann(12)**	**Observations of nearshore wave breaking, whitecapping, and large scale sand bar morphology**	**X**		**X**				
19	List(2)	Regional shoreline change						X	
20	Long(1)	Wind wave frequency-direction spectral measurements	X						
21	Miller(1), Resio(1)	Sediment transport rates during storms		X	X		X		
22	Sallenger(2)	Coastal applications of scanning airborne laser (LIDAR)						X	
23	**Smith(12)**	**Observations of waves and currents near the surf zone**	**X**	**X**					
24	Su(5), Teague(5)	Coastal breaking wave and bubble measurements							X
25	Svendsen(15), Grosskopf(26)	Models of nearshore circulation	X	X					
26	**Thornton(6), Stanton(6)**	**Nearshore wave & sediment processes**	**X**	**X**	**X**		**X**		
27	Trizna(5), Kirby(15)	Experimental tests of Boussinesq wave models in the near surf zone	X	X					
28	Trizna(5)	Marine radar remote sensing of bar & rip morphology						X	
29	Trowbridge(24)	Measurement of bottom stress in the wind- and wave-forced nearshore environment	X	X	X				
30	Wu(4), Shih(4), Kobayashi(15)	Nearshore water level profiles during storms	X						X

Measurements of the shoreface, seaward of the surf zone were made with bottom mounted instruments (6, 15, 29), and through geologic investigations (2, 14). Drs Wu and Shih made water level measurements (30).

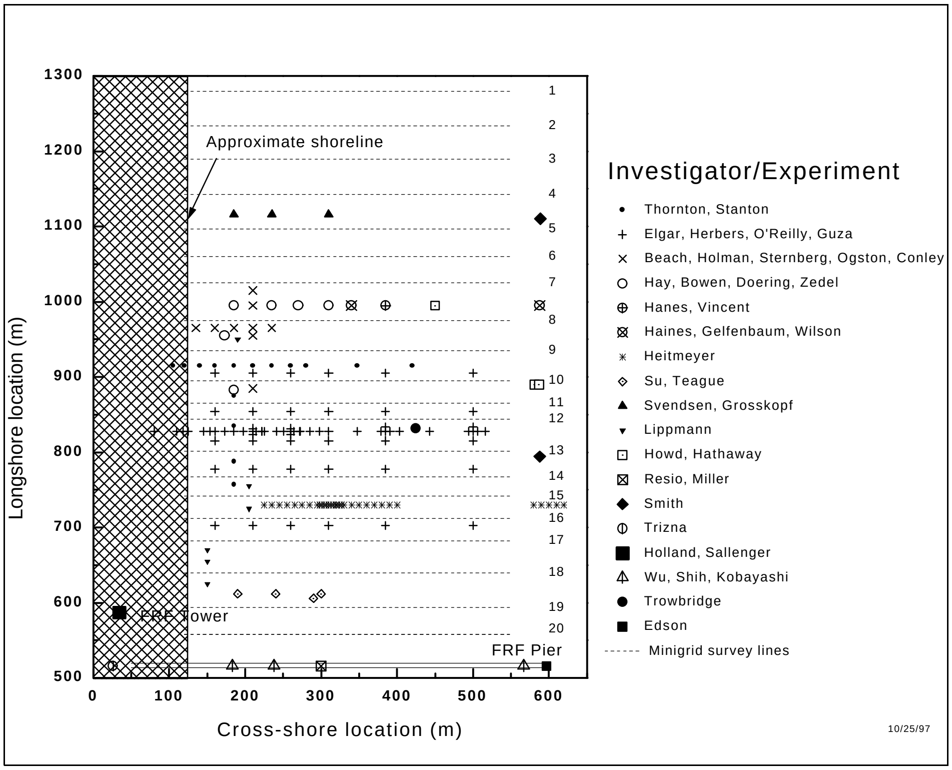

Figure 1. Layout of the SandyDuck surf zone array of instruments.

Surf zone and swash processes were observed with tower-mounted video systems (10, 12, 13, 18, 24) and land-based marine radar systems (27, 28). Nearshore acoustic behavior (9, 10) and bubble production (9, 24, 26) were also measured.

Each day the CRAB surveyed surf zone area known as the *minigrid*. These surveys were augmented by surveys over multi-km reaches of shoreline using GPS surveying all-terrain vehicles (12, 19), instrumented jet skis (1,3) and airborne systems (22).

RESULTS

The design of the surf zone instrument layout and the timing of the six-week experiment were based on previous studies of sandbar behavior at Duck and expectations that a wide range of conditions would occur. Figure 2 shows the wave conditions measured by a Datawell waverider buoy in 18-m of water. Incident wave height varied from calm (<0.5 m) to a short-lived peak of just over 3.5 m during the "SandyDuck storm" occurring between 18 and 22 October.

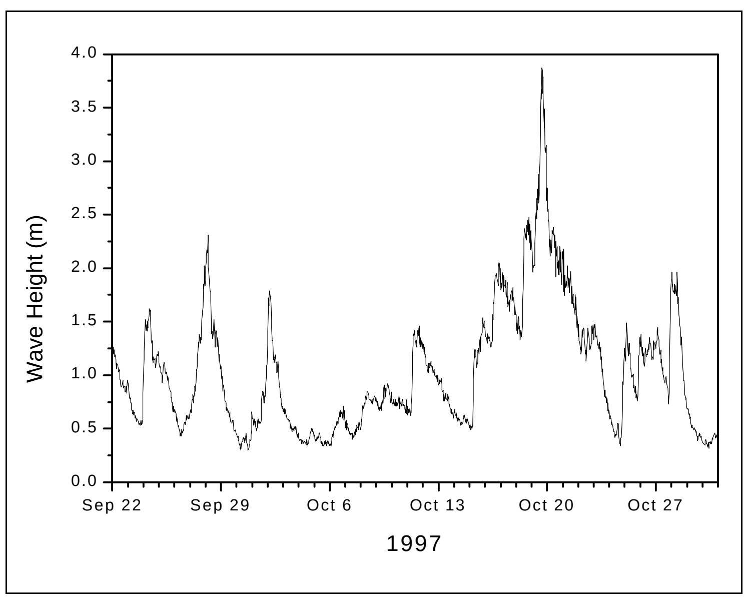

Figure 2. Wave conditions during SandyDuck.

However, although the nearshore sandbar moved throughout the experiment, it did not respond as expected during the storm. During earlier experiments such as DUCK85 in 1985 and DELILAH in 1990, the sandbar formed and moved offshore creating a linear longshore bar with a deep trough close to the beach. Highest observed longshore currents were found in this trough. As the storm passed, the linear bar developed rip channels and became highly three-dimensional. In contrast the SandyDuck sandbar remained three-dimensional the entire period and although it moved offshore during the storm, a deep inner trough never developed. The shape and evolution of the nearshore can be seen in the four minigrid surveys shown in Figure 3. One possible hypothesis for this response was that the outer bar, a low relief feature at offshore coordinate 350 m, caused sufficient energy dissipation to "protect" the inner bar. A second hypothesis is that the duration of the storm was insufficient to effectively rearrange the near-shore morphology. These ideas and many others will be the subject of future SandyDuck investigations.

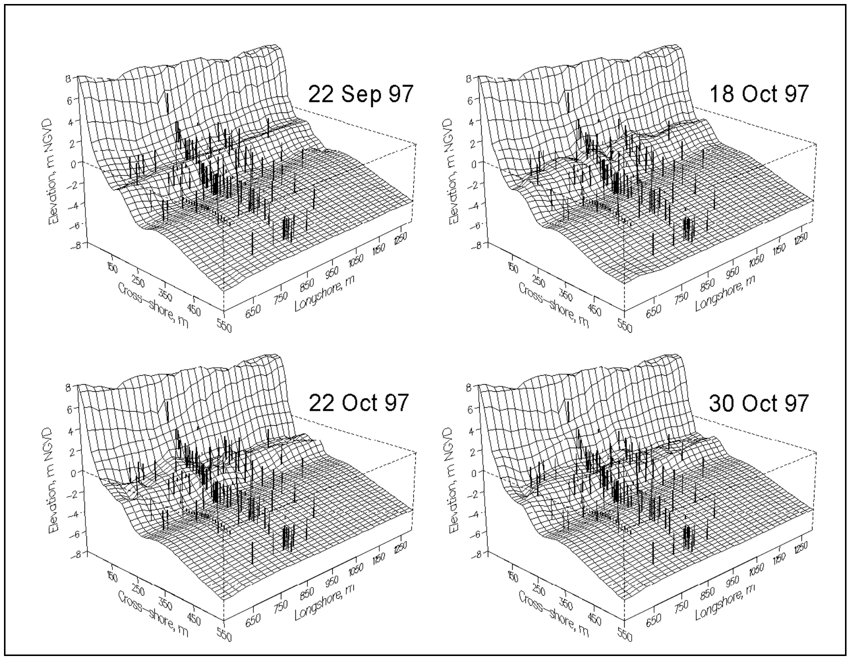

Figure 3. SandyDuck minigrid surveys including ones before and after the storm. Small vertical bars locate point sensors.

IMPACT/APPLICATION

The SandyDuck media effort coordinated by the three sponsoring agencies will have positive impacts for each organization as well as promoting the scientific study of the nations coasts. Print media included the New York Times, Virginia Pilot, the Associated Press and NC's Coastwatch. CNN's *Science and Technology Week*, CNN news, NY Times-TV *Science News*, the Weather Channel, and NC Public Television also covered the SandyDuck experiment.

REFERENCES

Birkemeier, W. A., Long, C. E., Hathaway, K. K., 1997, "DELILAH, DUCK94 & SandyDuck: Three Nearshore Field Experiments," Proceedings of the 25th International Conference on Coastal Engineering, Orlando, FL, ASCE.

Considerable SandyDuck information can be found on the web at: http://www.frf.usace.army.mil and linking to "SandyDuck."